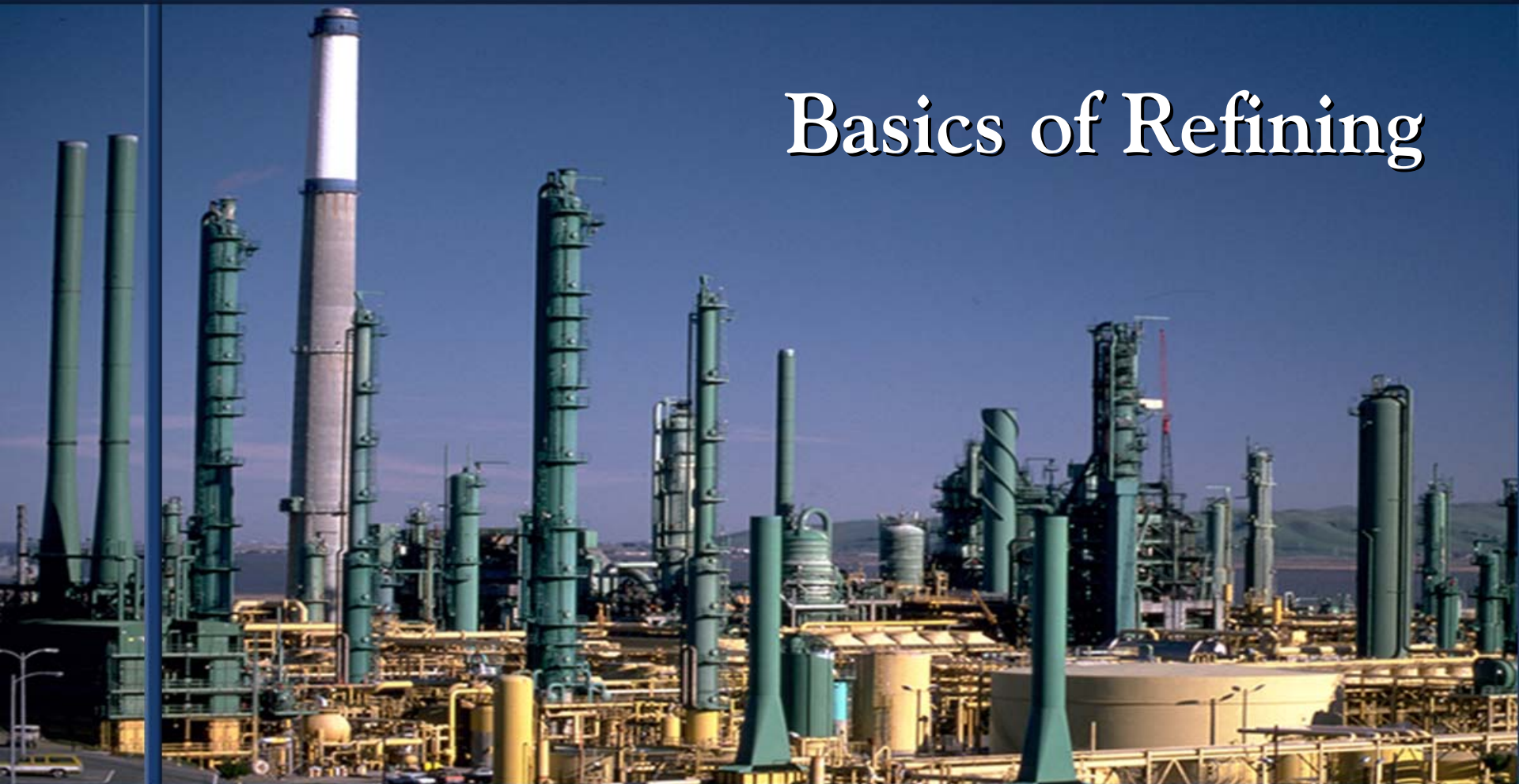


# Basics of Refining



**Refining Fundamentals & Impact of Changing Fuel Specifications**

# Safe Harbor Statement

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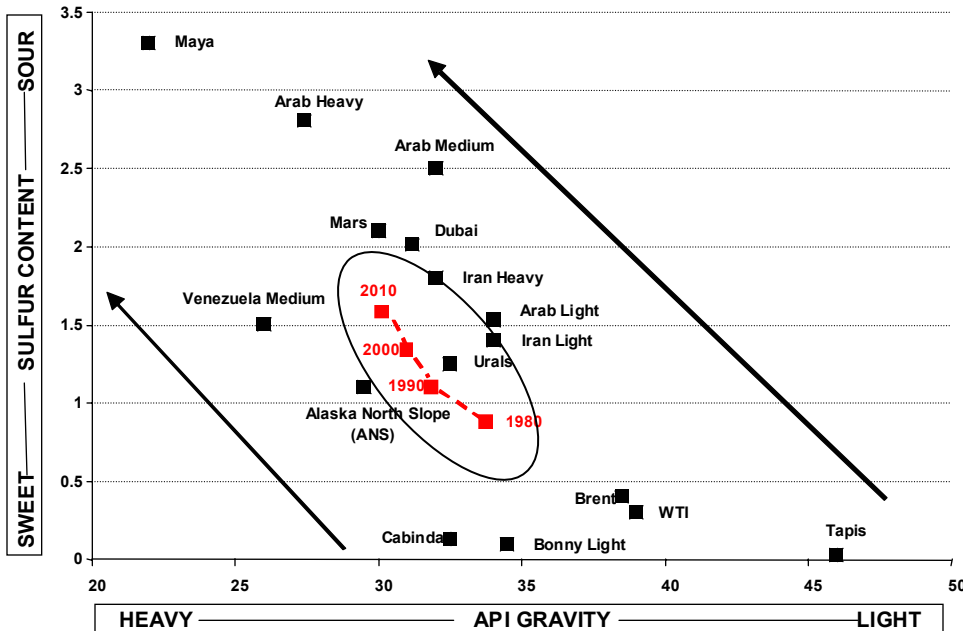
*Statements contained in this presentation that state the Company's or management's expectations or predictions of the future are forward-looking statements intended to be covered by the safe harbor provisions of the Securities Act of 1933 and the Securities Exchange Act of 1934. It is important to note that the Company's actual results could differ materially from those projected in such forward-looking statements. Factors that could affect those results include those mentioned in the documents that the Company has filed with the Securities and Exchange Commission.*

# Crude Oil Characteristics

- **Crude density is commonly measured by API gravity**
  - API gravity provides a relative measure of crude oil density ... the higher the API number, the lighter the crude
  - Classified as light, medium, or heavy
    - Light crudes are easier to process
    - Heavy crudes are more difficult to process
- **Sulfur content measures if a crude is sweet (low sulfur) or sour (high sulfur)**
  - Less than 0.7% sulfur content = sweet
  - Greater than 0.7% sulfur content = sour
  - High sulfur crudes require additional processing to meet regulatory specs
- **Acid content measured by Total Acid Number (TAN)**
  - Acidic crudes highly corrosive to refinery equipment
  - High acid crudes are those with  $TAN > 0.7$

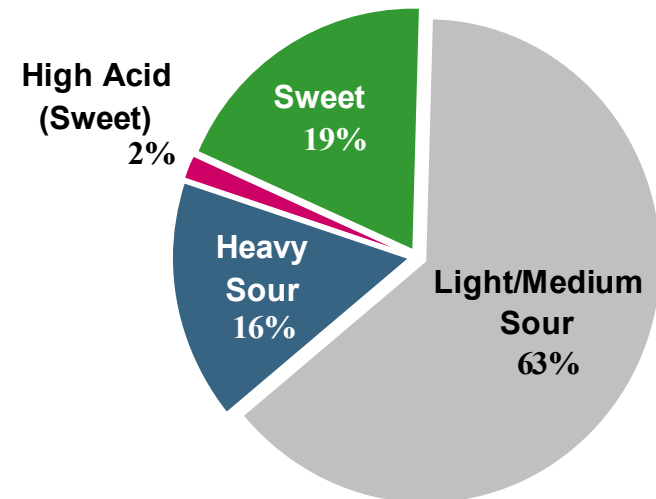
# Crude Oil Basics

Crude Quality by Types



Source: Simmons & Co.

Estimated Quality of Reserves (2005)



Source: Oil & Gas Journal, Company Information

- Majority of global reserves are light/medium sour
- Most quoted benchmark prices are light sweet crudes
  - WTI (West Texas Intermediate), Western Hemisphere
  - Brent (North Sea Crude), Europe

# Basic Refining Concepts

## Crude Types

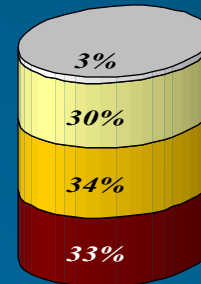
## Characteristics

## Yields

## 2004 U.S. Refinery Production

**Sweet Crude**  
(i.e. WTI, Brent)

34+ API Gravity  
< 0.7 % Sulfur  
35% Demand  
Most Expensive

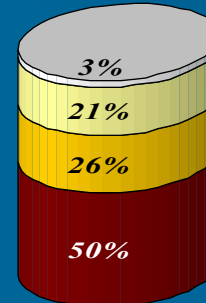


8% Propane/  
Butane



**Medium Sour Crude**  
(i.e. Mars, Arab Light,  
Arab Medium)

24 - 34 API Gravity  
> 0.7 % Sulfur  
50% Demand  
Less Expensive

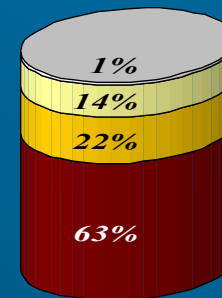


49% Gasoline  
RFG  
Conventional  
CARB  
Premium



**Heavy Sour Crude**  
(i.e. Maya)

< 24 API Gravity  
> 0.7 % Sulfur  
15% Demand  
Least Expensive



32% Distillate  
Jet Fuel  
Diesel  
Heating Oil



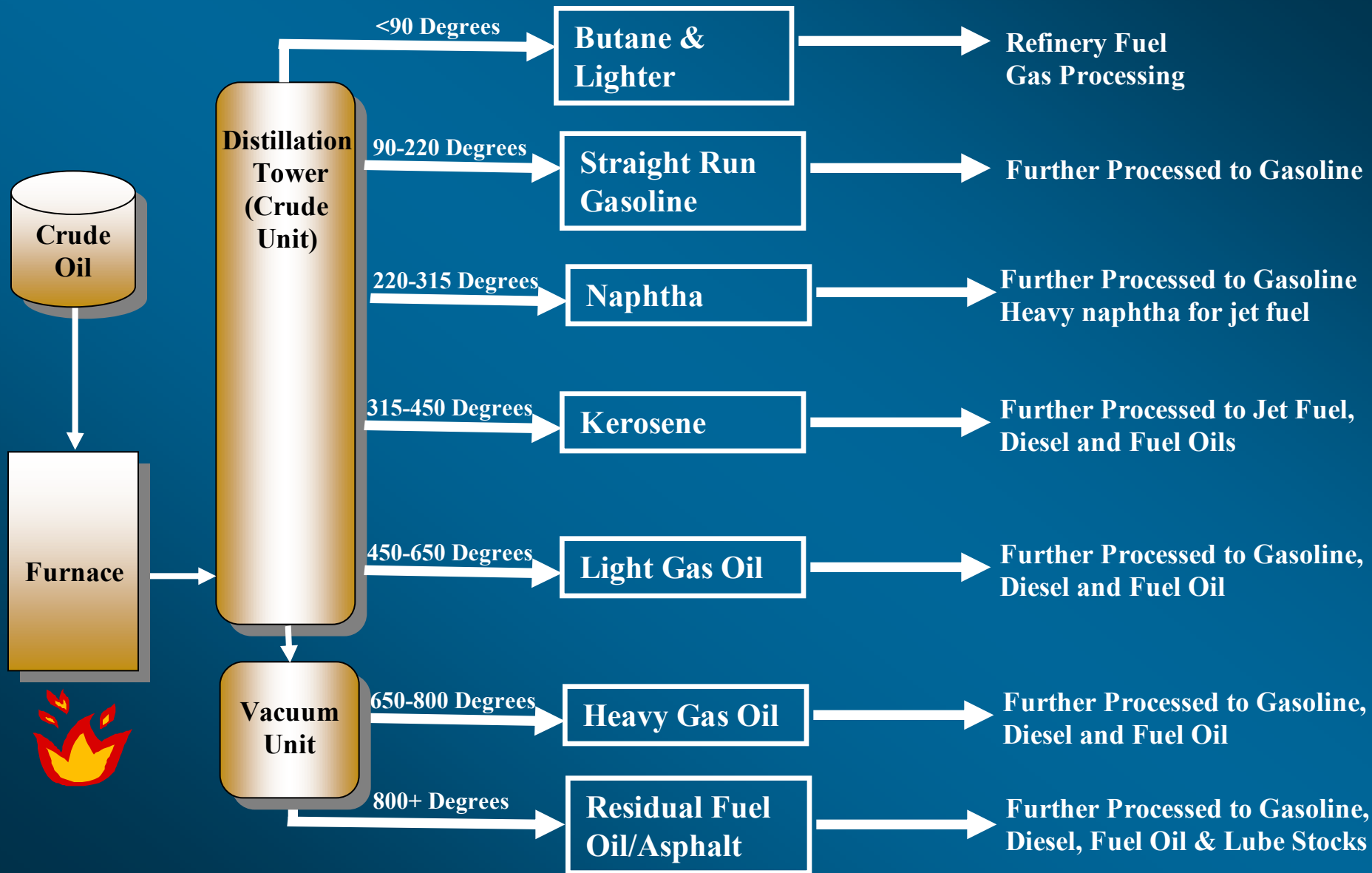
11% Heavy  
Fuel Oil  
& Other



Source: EIA Refiner Production

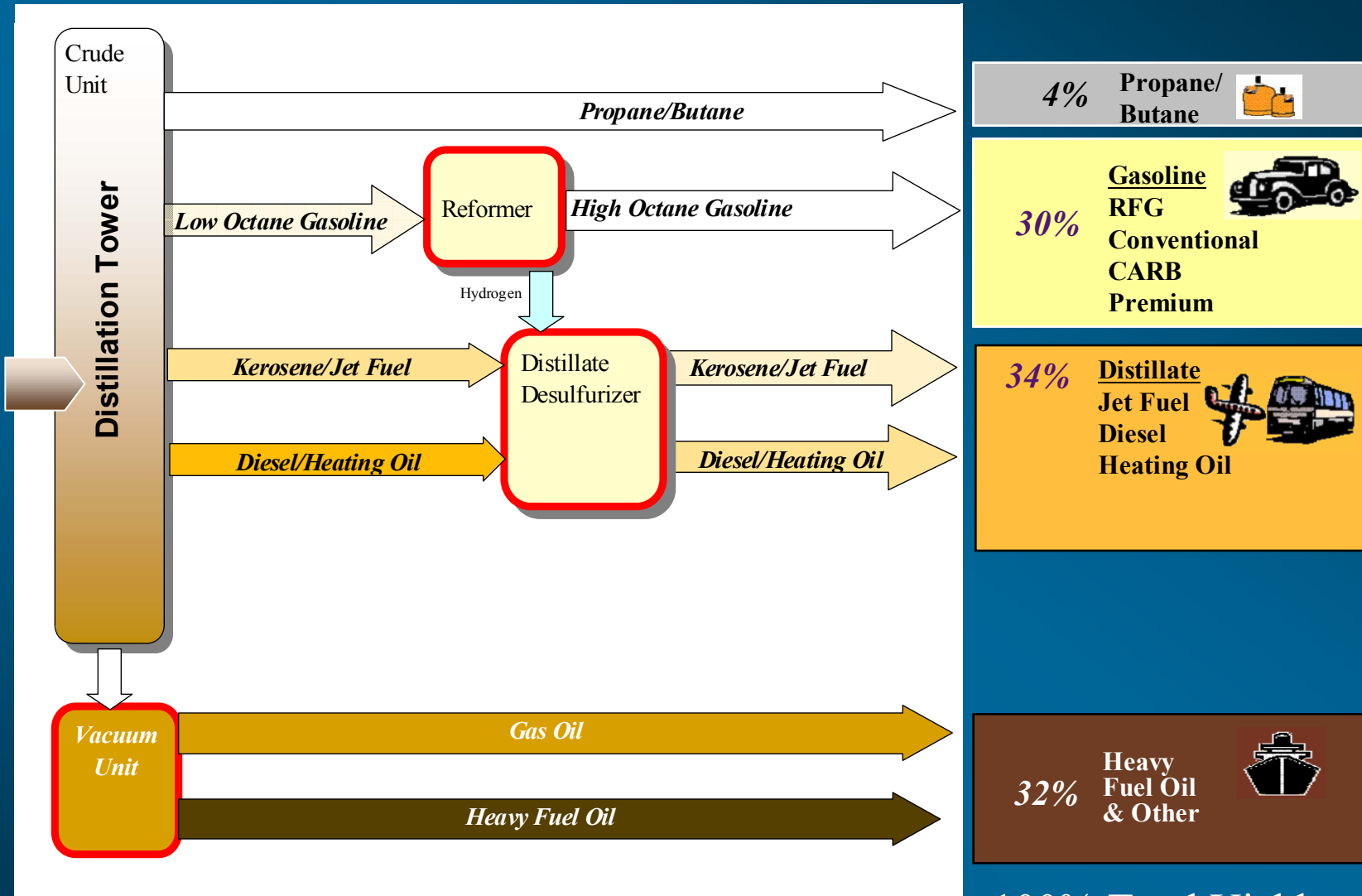
Refineries upgrade crude oil to higher value products

# Basic Refining Concepts



# Hydroskimming Refineries – Distillation Process

Light  
Sweet  
Crude

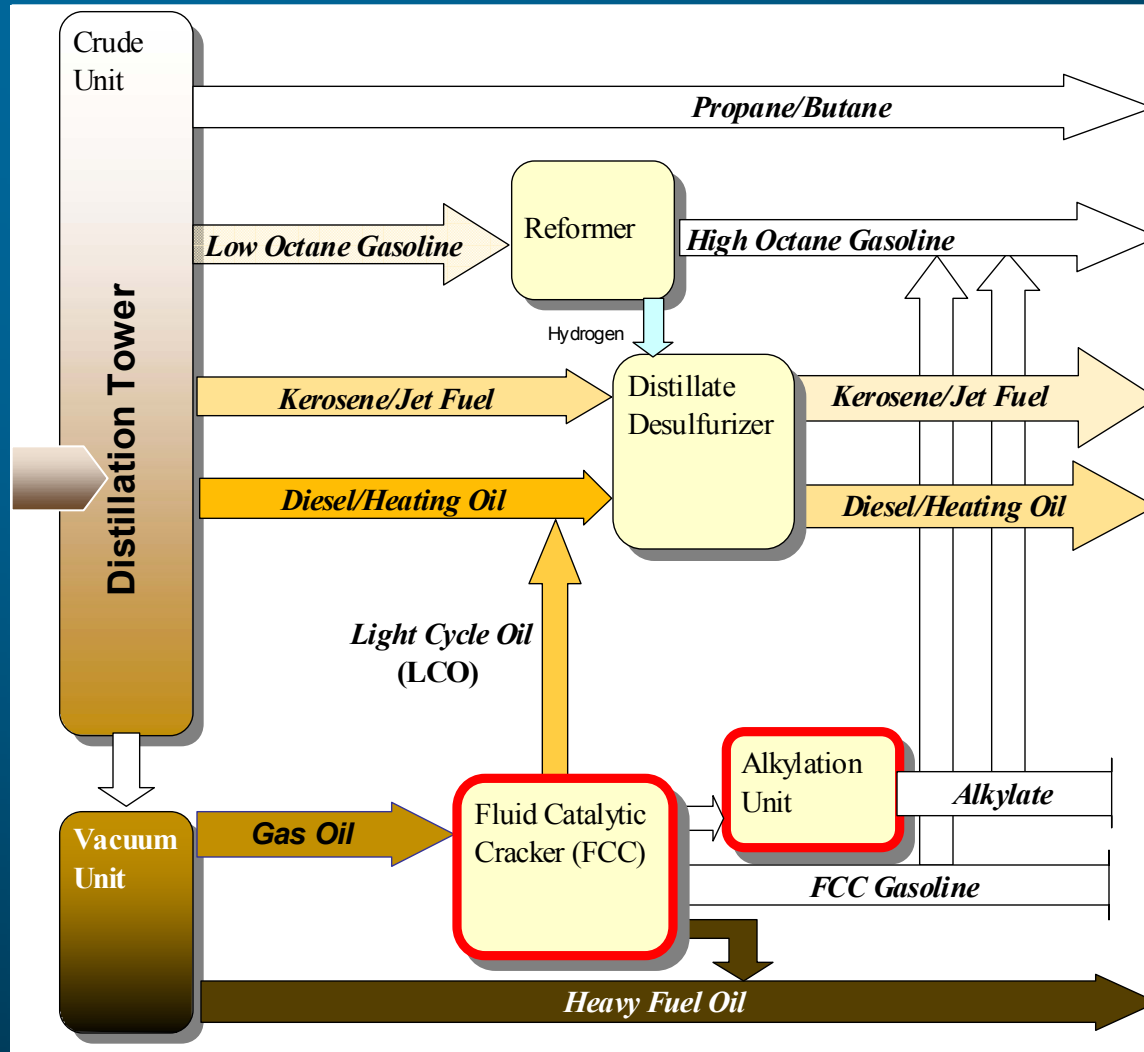






100% Total Yield

Simple low upgrading capability refineries tend to run sweet crude

# Medium Conversion Refineries - Catalytic Cracking

Light Sour Crude



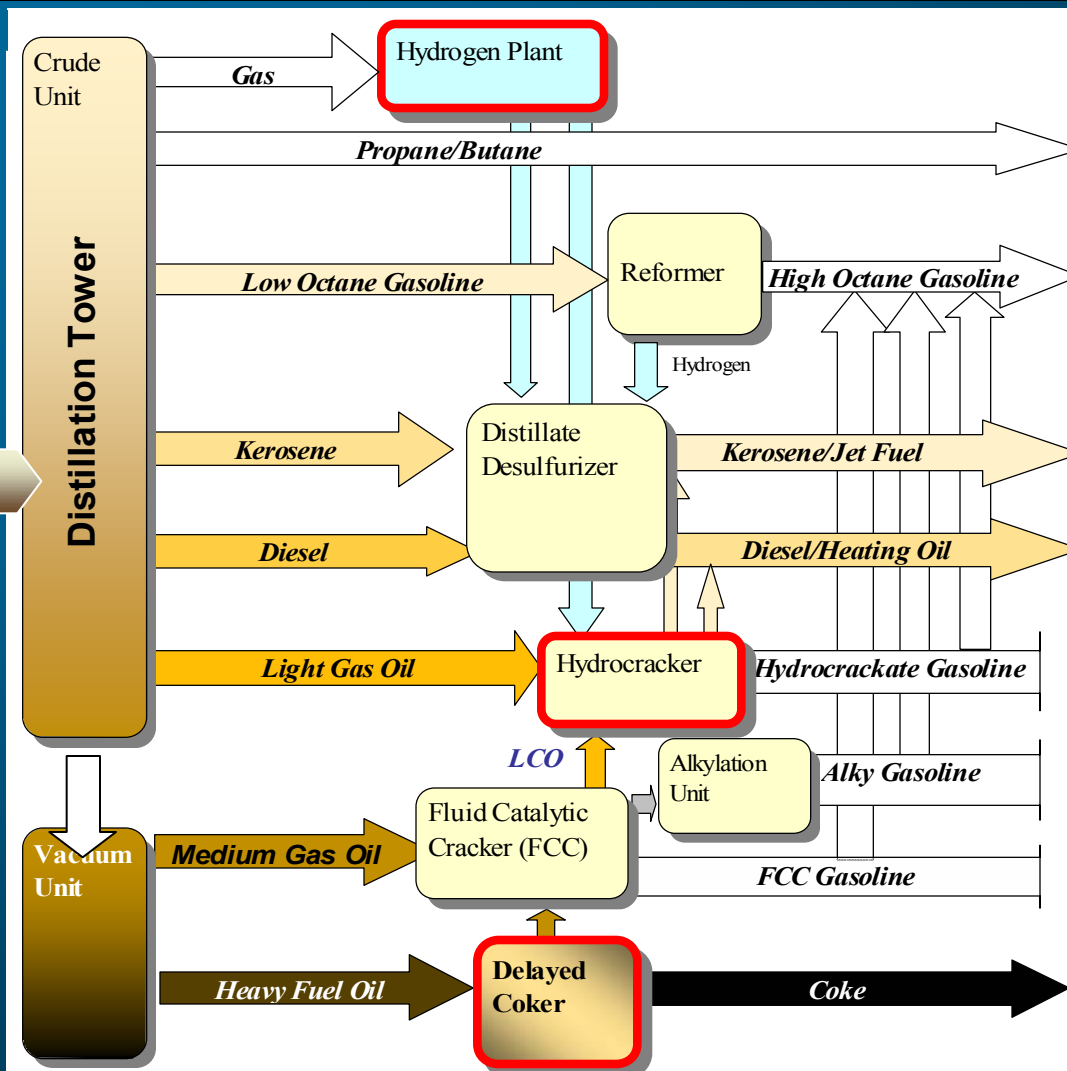
8%	Propane/ Butane	
45%	Gasoline RFG Conventional CARB Premium	
27%	Distillate Jet Fuel Diesel Heating Oil	
24%	Heavy Fuel Oil & Other	

104% Total Yield

Moderate upgrading capability refineries tend to run more sour crudes while achieving increased higher value product yields and volume gain.

# High Conversion Refineries – Coking/Resid Destruction

Medium/  
Heavy  
Sour  
Crude



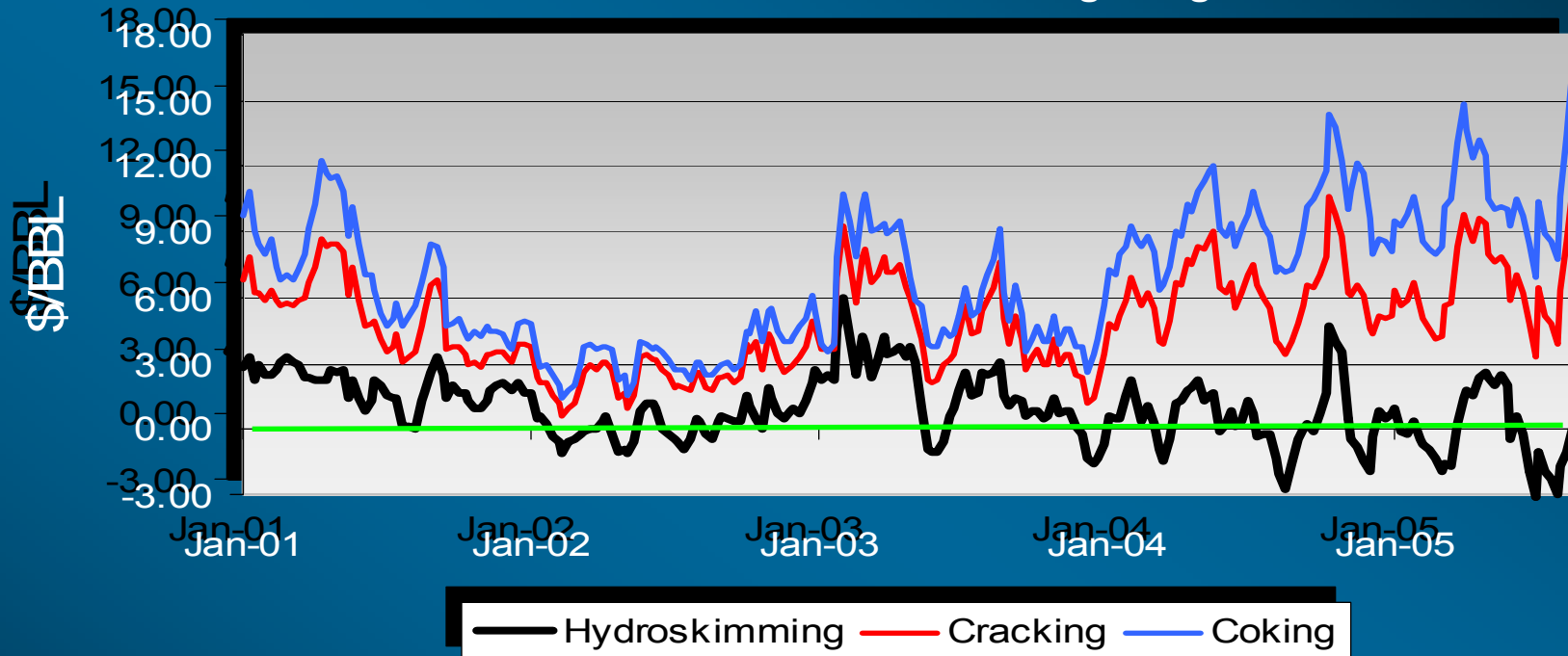
7%	Propane/ Butane	
58%	Gasoline RFG Conventional CARB Premium	
28%	Distillate Jet Fuel Diesel Heating Oil	
15%	Heavy Fuel Oil & Other	

108% Total Yield

Complex refineries can run heavier and more sour crudes while achieving the highest light product yields and volume gain.

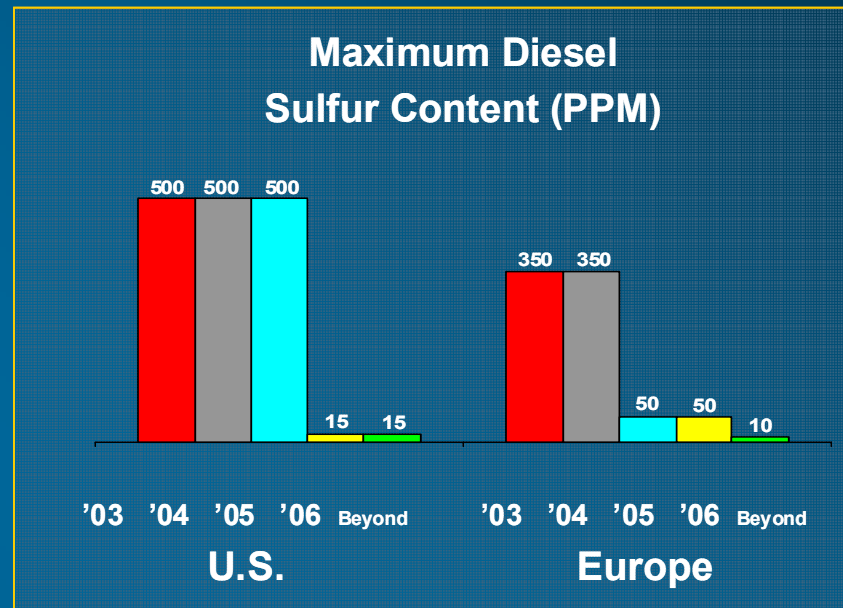
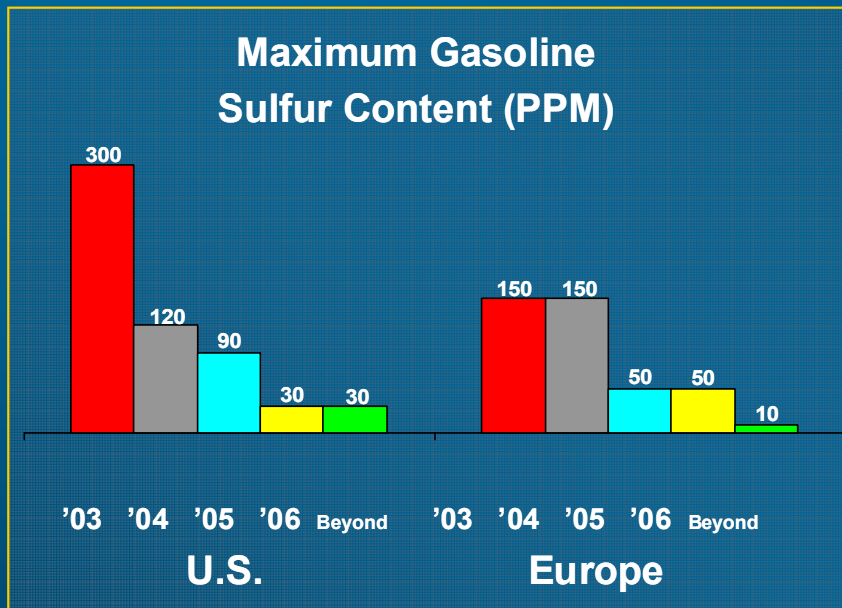
# Conversion Economics

USGC Medium Sour Crude Refining Margins



- **Conversion capacity needed to capitalize on sour crude discounts**
  - **Hydroskim** - Breakeven or moderate margins; High resid yield
    - When margins are positive - increase crude runs
    - When margins are negative - decrease crude runs
  - **Cracking** - Better margins; Lower resid yield
  - **Coking** - Best margins; Lowest resid yield
    - Maximize heavy crudes

# Regulatory Changes Impacting Supply



## ■ Major changes in sulfur specs

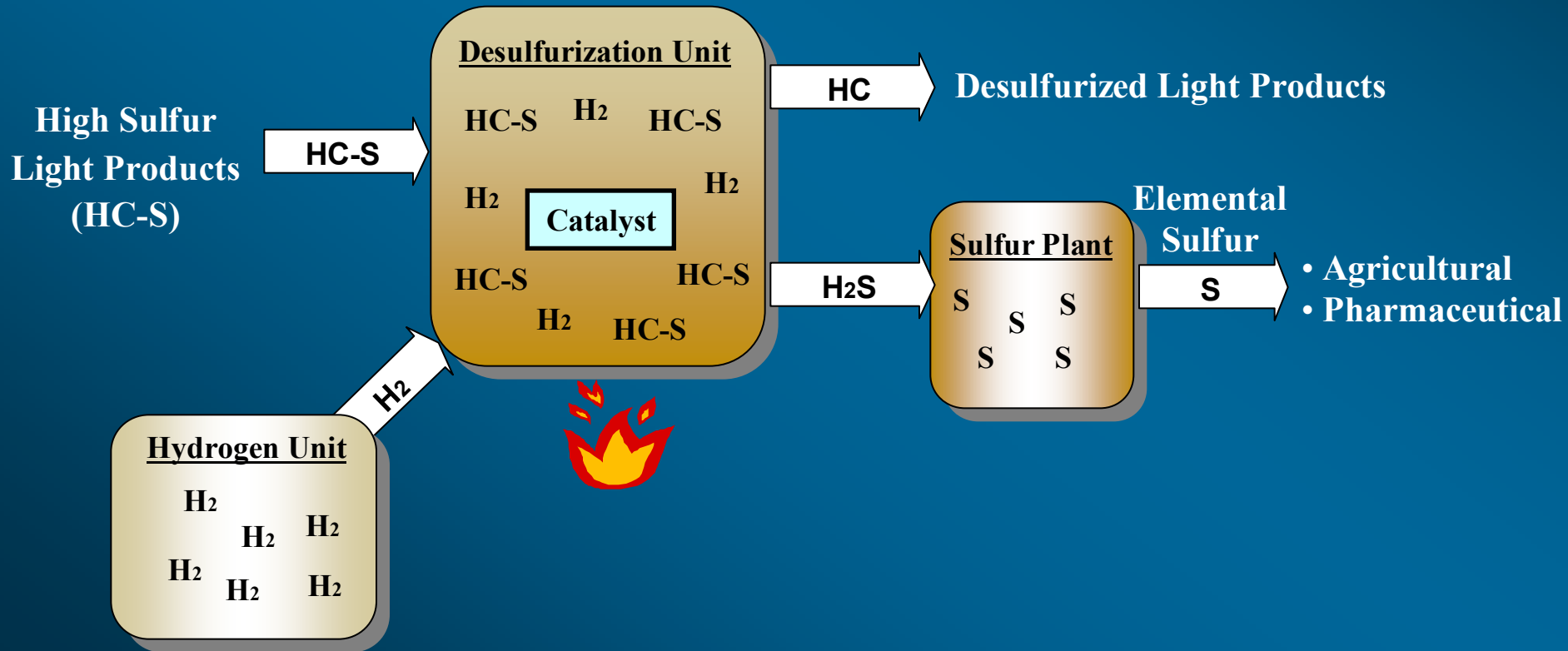
- 2005 in Europe and 2006 in U.S.

# Desulfurization Basics

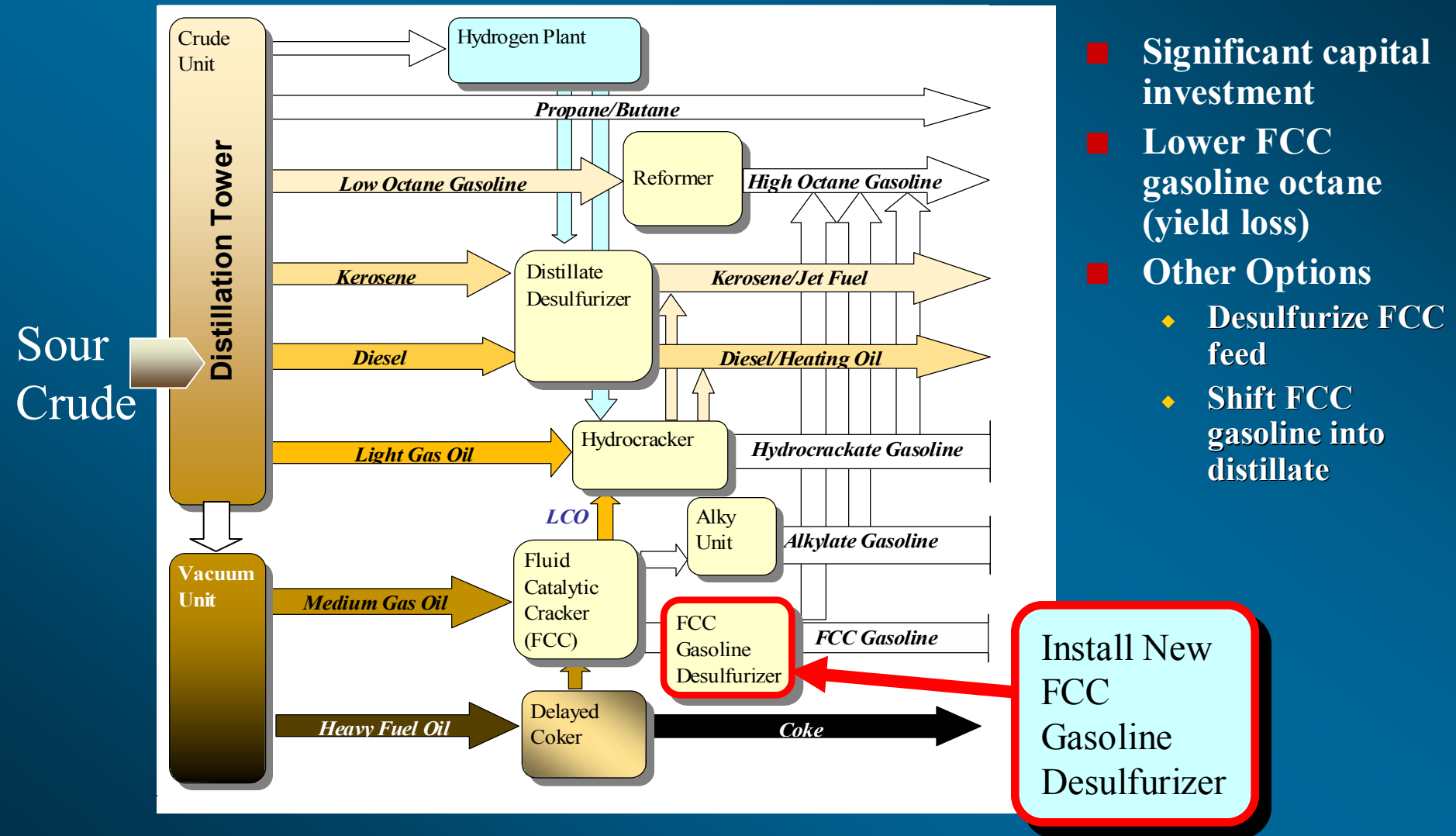
## ■ Goal

- ◆ Removal sulfur from light products (gasoline or diesel) to meet air quality requirements for clean burning fuels

## ■ Process



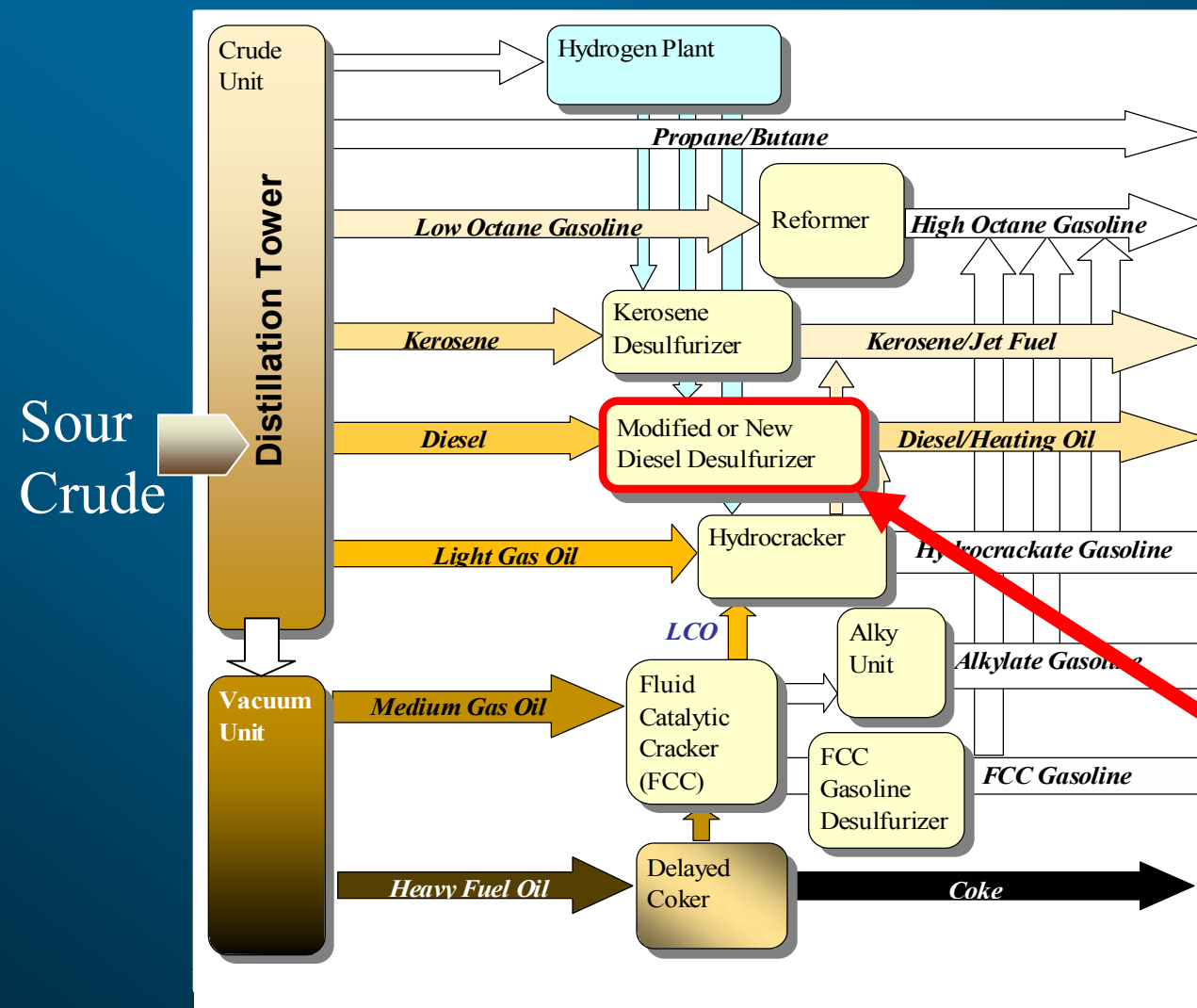
# Gasoline Desulfurization



- Significant capital investment
- Lower FCC gasoline octane (yield loss)
- Other Options
  - ◆ Desulfurize FCC feed
  - ◆ Shift FCC gasoline into distillate

Install New  
FCC  
Gasoline  
Desulfurizer

# Diesel Desulfurization



- Significant capital investment
- Significant project management time and focus
- Diesel yield loss

Install New Diesel Desulfurizer or Modify Existing Desulfurizer

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# Appendix

# Major Refining Processes

## Category

## Definition

## Process

Topping  
(Separation of Crude)

Separating crude oil into different hydrocarbon groups. The most common means is through distillation.

Desalting – Prior to distillation, crude oil is often desalted to remove corrosive salts as well as metals and other suspended solids.

Atmospheric Distillation – Used to separate the desalted crude into specific hydrocarbon groups (straight run gasoline, naphtha, light gas oil, etc.) or fractions.

Vacuum Distillation – Heavy crude residue (“bottoms”) from the atmospheric column is further separated using a lower-pressure distillation process. Means to lower the boiling points of the fractions and permit separation at lower temperatures, without decomposition and excessive coke formation.

# Major Refining Processes

## Category

## Definition

## Process

Thermal and  
Catalytic Cracking

“Cracking” or breaking down large, heavy hydrocarbon molecules into smaller hydrocarbon molecules thru application of heat or thru the use of catalysts.

Coking – Thermal non-catalytic cracking process that converts low value oils to higher value gasoline, gas oils and marketable coke. Residual fuel oil from vacuum distillation column is typical feedstock.

Visbreaking – Thermal non-catalytic process used to convert large hydrocarbon molecules in heavy feedstocks to lighter products such as fuel gas, gasoline, naphtha and gas oil. Produces sufficient middle distillates to reduce the viscosity of the heavy feed.

Catalytic Cracking – A central process in refining where heavy gas oil range feeds are subjected to heat in the presence of catalyst and large molecules crack into smaller molecules in the gasoline and surrounding ranges.

Catalytic Hydrocracking – Like cracking, used to produce blending stocks for gasoline and other fuels from heavy feedstocks. Introduction of hydrogen in addition to a catalyst allows the cracking reaction to proceed at lower temperatures than in catalytic cracking, although pressures are much higher.

# Major Refining Processes

## Category

## Definition

## Process

Combination/  
Rearrangement of  
Hydrocarbons

Linking two or more hydrocarbon molecules together to form a large molecule (e.g. converting gases to liquids).

Alkylation – Important process to upgrade light olefins to high-value gasoline components. Used to combine small molecules into large molecules to produce a higher octane product for blending with gasoline.

Catalytic Reforming – The process where naphthas are changed chemically to increase their octane numbers. Octane numbers are measures of whether a gasoline will knock in an engine. The higher the octane number, the more resistance to pre or self-ignition.

Polymerization – Process that combines smaller molecules to produce high octane blending stock.

Isomerization – Process used to produce compounds with high octane for blending into the gasoline pool. Also used to produce isobutene, an important feedstock for alkylation.

Ethers Manufacture – Alcohols and ethers (MTBE) are added to gasoline to increase octane levels and reduce generation of carbon monoxide.

# Major Refining Processes

## Category

## Definition

## Process

Treating

Processing of petroleum products to remove some of the sulfur, nitrogen, heavy metals and other impurities

Catalytic Hydrotreating, Hydroprocessing, sweetening/sulfur removal – Used to remove impurities (e.g. sulfur, nitrogen, oxygen and halides) from petroleum fractions. Hydrotreating further “upgrades” heavy feeds by converting olefins and diolefins to parafins, which reduces gum formation in fuels. Hydroprocessing also cracks heavier products to lighter, more saleable products.